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(19)

(54) IMPROVEMENTS RELATING TO MOTOR-IN-WHEEL UNITS

(71) We, NEWAGE ENGINEERS LIMITED, a Company registered under the laws of England, of Park Works, Barnack Road, Stamford, PE9 2NB, Lincolnshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to hub drives with reduction gear mechanisms, for example, a drive for a motor-in-wheel unit of the kind comprising a stationary structure including a motor housing provided with flange means for mounting the unit on a vehicle chassis, a driving motor housed in the motor housing, and a wheel, the motor housing being surrounded by the rim of the wheel whose hub is journalled for rotation relative to the stationary structure, and the hub being driven from the motor driving shaft through a reduction gear mechanism mounted at one end of the motor housing.

According to the present invention, a hub drive comprises a wheel hub, and a reduction gear mechanism having a rigid carrier structure which comprises an inner carrier member which in use is situated at one end of a driving motor, and an outer carrier member which is rigidly secured to the inner carrier member in spaced side-by-side relationship therewith by a set of rigid reaction pins which extend between them, and in which the reduction gear mechanism is of the gyratory type which comprises an input shaft journalled in bearings in the carrier structure, which shaft in use is driven by the motor, the wheel hub being journalled coaxially with the input shaft, an internally-toothed output gear ring formed on or rigidly secured to the wheel hub coaxially therewith and in meshing engagement with at least one externally-toothed intermediate gear pinion which is journalled on the crank of an eccentric crank mechanism whose crankshaft is comprised by the input shaft, the reaction pins extending parallel to the input shaft axis through oversize apertures in the or each intermediate gear pinion, whereby the drive of the input shaft is transmitted with speed reduction to the output gear ring and thence to the wheel hub through the or each intermediate gear pinion which is driven in a circular orbital path around the reaction pins which restrain it from bodily rotation about its own axis, and the hub drive being provided with a friction brake acting between the input shaft and the carrier structure to brake the input shaft, the brake being located on the side of the reduction gear mechanism which in use is remote from the driving motor, and the braking torque reaction thereof being transmitted to the outer carrier member and thence via the reaction pins to the inner carrier member.

In one arrangement the inner carrier member is detachably secured to one end of a housing for the driving motor.

Conveniently the brake is of multi-plate type, having one set of annular friction plates axially-slidably mounted on the input shaft and coupled thereto for rotation therewith, and having a second set of annular friction plates respectively interposed between and co-operating with the plates of the first set, the second set of plates being restrained from rotation by a set of anchorage pins secured to and projecting in the axial direction from the outer carrier member the plates of the second set being axially-slidable along the anchorage pins.

For operating the brake, an elongated operating member may be provided which extends through an axial bore in the input shaft and, when the hub drive is mounted on the motor housing, through an aligned axial bore in the motor driving shaft, for cooperation with a brake actuator member for applying axial pressure to the stack of interposed annular plates.

Alternatively the axial thrust required to actuate the brake may be transmitted hydraulically to the brake assembly.

In either case, the axial thrust required to operate the brake is reacted against the rigid carrier structure, this structure providing axial reaction independently of the intermediate pinions of the reduction gear mechanism,

so that these pinions are not relied on to provide such axial reaction.

According to a further feature of the invention, the wheel hub may be journalled by means of tapered roller bearings on the inner and outer carrier members respectively, these bearings being axially located, and preferably axially adjustable, by means of a set of removable shims secured by a clamping member which is itself secured by bolts or screws to the outer carrier member, and the braking torque reaction may be transmitted through these bolts or screws to the outer carrier member and hence via the reaction pins to the inner carrier member and motor housing.

The invention may be carried into practice in various ways, but one specific embodiment will now be described by way of example only and with reference to the accompanying drawings, in which:—

Figure 1 is an outline side elevation of a motor-in-wheel unit, showing its reduction gear and brake mechanism in axial section;

Figure 2 is a sectional view on a larger scale than Figure 1 showing the brake mechanism in detail; and

Figure 3 is an end elevation of the unit of Figure 1, half in cross-section on the line III—III of Figure 1.

In the illustrated embodiment a wheel rim 10 carrying a tyre 10A surrounds a housing 11 for an electric driving motor 12 whose driving shaft 13 is partly shown in the drawing, and to one end of the housing 11 a reduction gearbox 14 is bolted by means of bolts 15. The reduction gearbox 14 comprises a rotary input shaft 16 which is coupled coaxially by a splined connection 17 to the end of the motor shaft 13, and which has two axially-spaced circular eccentrics 18, 19 of equal eccentricity, on which a pair of intermediate gear pinions 20 and 21 are respectively journalled by means of roller bearings 20A, 21A. The intermediate pinions 20 and 21 have equal numbers of external gear teeth in meshing engagement with the greater number of internal gear teeth 22 of an output gear ring constituting the wheel hub 23. The hub 23 has flanges 24 to which the wheel rim 10 is bolted by means of bolts or studs 25 and nuts 26. The motor housing 11 carries an integral flange 27 for mounting the whole unit on a vehicle chassis.

The input shaft 16 is journalled by means of a roller bearing 28 in an inner annular carrier member 29 which is bolted to the end face of the motor housing 11 by means of the bolts 15, and in an outer annular carrier member 30 by a ball bearing 31. The inner carrier member 29 has an annular spigot 32 which locates inside a socket portion 33 of the motor housing 11. The wheel hub 23 is journalled on the outer carrier member 30 by means of a tapered roller bearing 34A, and on the inner carrier member 29 by means of a tapered roller bearing 34B.

The outer annular carrier member 30 is rigidly secured to the inner carrier member 29 in spaced coaxial relationship thereto by means of six rigid pins 35 which also act as the reaction pins for the reduction gear mechanism. Each pin 35 has a head 36 at its outer end outside the outer carrier member 30 and is secured at its inner end by a screw 37 to the inner carrier member 29. A cylindrical spaced sleeve 39 surrounds each reaction pin 35, and by tightening up the screws 37 the assembly of inner and outer carrier members 29 and 30 and reaction pins 35 is clamped together rigidly at the predetermined spacing dictated by the spacer sleeves 38. The reaction pins 35 are prevented from rotation by transverse pins 39 each extending in aligned bores in a pin 35 and in the outer carrier member 30. The two intermediate gear pinions 20 and 21 lie between the inner and outer carrier members 29 and 30, and the reaction pins 35 and their spacer sleeves 38 extend through circular apertures 40 in the intermediate pinions. A pair of cylindrical bushes 41 are journalled on the exterior of each spacer sleeve 38, the bore of each bush 41 being oversize with respect to the external diameter of the spacer sleeve so that the bush lubricant film acts as a hydrodynamic bearing, and the cylindrical exteriors of the two bushes 41 bear against the interiors of the respective surrounding circular apertures 40 in the two intermediate pinions 20 and 21, to transmit the reaction of the reduction gearing to the reaction pins 35 and hence to the inner carrier member 29 and to the motor housing 11, in the manner described in our British patent specification No. 1,145,266. The diameter of each aperture 40 is greater than the external diameter of the associated bush 41 by an amount equal to twice the radial eccentricity of the associated eccentric 18 or 19. Moreover, the pitch circle diameter of the teeth 22 of the output gear ring 23 is greater than the pitch circle diameter of the teeth of each of the intermediate pinions 20 and 21 by an amount equal to twice the radial eccentricity of the associated eccentric 18 or 10.

Thus when the driving motor is energised, its driving shaft 13 rotates the input shaft 16 and the rotating eccentrics 18 and 19 cause their associated intermediate gears 20 and 21 to gyrate, the bushes 41 rolling around the edges of the apertures 40 and rotating on the spacer sleeves 38 of the reaction pins 35 so that each of the intermediate pinions 20, 21 travels in a circular orbital path around each of the reaction pins 35 but is prevented from rotating about its own axis by its engagement with the reaction pins 35. This gyratory movement of each intermeditae pinion 20, 21 causes its point of meshing engagement with the teeth 22 of the hub 23 to travel around

the intermediate pinion which has a smaller number of teeth than the hub, causing a rotation of the hub at a differential speed and thus transmitting the drive of the motor shaft 13 to the wheel with the required speed reduction. To balance the radial thrust the eccentrics 18 and 19 are 180° out of phase with one another, as are the two intermediate pinions 20 and 21.

The motor-in-wheel unit is provided with a friction brake of multiple-plate type comprising a first set of six inner annular friction plates 45 which are keyed or splined to the outer end of the input shaft 16, as indicated at 46, so that the plates 45 are free to move axially along the input shaft 16 whilst being driven by the shaft, and a second set of outer annular friction plates 47. The outer brake plates 47 are formed with external slots in which are engaged a set of rigid axially-extending anchor bolts 48 screwed into tapped holes 49 in the outer carrier member 30, whereby the outer brake plates 47 are free to slide axially along the anchor bolts 48 whilst being prevented from rotation by the bolts 48. A brake actuating plate 50 of dished form has its outer periphery under-lying an annular clamp plate 51 which is bolted to the exterior of the outer carrier member 30 by the anchor bolts 48. The clamp plate 51 also locates axially the inner race of the tapered roller bearing 34A, bearing adjustment shims 52 being interposed between the parts 51 and 30 to allow correct assembly and axial adjustment of the tapered roller bearings 34A and 34B. The anchor bolts 48 pass through slots in the rim of the brake actuating plate 50 to prevent rotation of the latter. A brake pull rod 53 exends longitudinally through an axial bore in the motor driving shaft 18 and an aligned axial bore in the input shaft 16, and carries a head 54 at its left hand end in the drawing which overlies the exterior of the brake actuating plate 50. At its other end, the rod 54 protrudes from the motor housing 11 and is coupled to a brake operating linkage, not shown, which when operated pulls the rod 53 towards the right in the drawing to cause its head 54 to press the actuating plate 50 against the stack of interposed inner and outer brake plates 45 and 47, thereby applying the brake. The resultant frictional braking torque acts on the input shaft 16 and thence on the motor shaft 18, and the torque reaction is transmitted from the outer brake plates 47 through the anchorage bolts 48 to the outer carrier member 30, and thence via the reaction pins 35 to the inner carrier member 29 and so to the fixed motor housing 11. A brake return spring 55 acts between the input shaft 16 and the brake actuating plate 50 to assist in brake disengagement. The clamp plate 51 acts as a stop limiting outward movement of the brake actuating plate 50.

The diameter 56 of the outer carrier member 30 on which the outer hub bearing 34A sits has six scallops 57 which accommodate the heads 36 of the reaction pins 35. The journal bearing 31 for the input shaft 16 in the outer carrier member 30 is a ball bearing located by a snap ring 59 and provides axial location for the input shaft 16 in the reduction gearing assembly. A clamping ring 60 traps the snap ring 59 against the carrier member 30 and is secured to the carrier member 30 by countersunk screws 61.

When the pull rod 53 is pulled to operate the brake, the axial brake-operating thrust is reacted via the stack of plates 45, 47 and the clamping ring 60 directly to the outer carrier member 30, and thence via the reaction pins 35 to the inner carrier member 29 and the motor housing 11.

The reduction gear mechanism is provided with a dished hub cover plate 63 which is secured to the wheel hub 23 by screws 64. The cover plate 63 has a breather 65 in its centre.

After the wheel rim 10 has been removed from the flange 24 of the hub 23 by removal of the nuts 26 from the bolts 25 and withdrawal of the wheel rim assembly to the right in the drawing, the complete reduction gear asssembly 14 can be removed from the motor housing 11 (which in use is fixed to the frame of the vehicle by the mounting flange 27) by unscrewing the bolts 15 from the housing portion 2 by means of an Allen key passed through scallops 66 in the flange 24 of the wheel hub 23. The spigot 32 can then be withdrawn from the housing portion 33 for the complete removal of the gearbox assembly 14 from the motor housing 11.

WHAT WE CLAIM IS:—

1. A hub drive which comprises a wheel hub, and a reduction gear mechanism having a rigid carrier structure which comprises an inner carrier member which in use is situated at one end of a driving motor, and an outer carrier member which is rigidly secured to the inner carrier member in spaced side-by-side relationship therewith by a set of rigid reaction pins which extend between them, and in which the reduction gear mechanism is of the gyratory type which comprises an input shaft journalled in bearings in the carrier structure, which shaft in use is driven by the motor, the wheel hub being journalled coaxially with the input shaft, an internally-toothed output gear ring formed on or rigidly secured to the wheel hub coaxially therewith and in meshing engagement with at least one externally-toothed intermediate gear pinion which is journalled on the crank of an eccentric crank mechanism whose crankshaft is comprised by the input shaft, the reaction pins extending parallel to the input shaft axis through oversize apertures in the or

each intermediate gear pinion, whereby the drive of the input shaft is transmitted with speed reduction to the output gear ring and thence to the wheel hub through the or each intermediate gear pinion which is driven in a circular orbital path around the reaction pins which restrain it from bodily rotation about its own axis, and the hub drive being provided with a friction brake acting between the input shaft and the carrier structure to brake the input shaft, the brake being located on the side of the reduction gear mechanism which in use is remote from the driving motor, and the braking torque reaction thereof being transmitted to the outer carrier member and thence via the reaction pins to the inner carrier member.

2. A hub drive as claimed in Claim 1, in which the inner carrier member is detachably secured to one end of a housing for the driving motor.

3. A hub drive as claimed in Claim 1 or Claim 2, in which the brake is of multi-plate type, having one set of annular friction plates axially-slidably mounted on the input shaft and coupled thereto for rotation therewith, and having a second set of annular friction plates respectively interposed between and cooperating with the plates of the first set, the second set of plates being restrained from rotation by a set of anchorage pins secured to and projecting in the axial direction from the outer carrier member, the plates of the second set being axially-slidable along the anchorage pins.

4. A hub drive as claimed in Claim 3, in which for operating the brake an elongated operating member extends through an axial bore in the input shaft for cooperation with a brake actuator means for applying axial pressure to the stack of interposed annular plates.

5. A hub drive as claimed in any preceding Claim in which the wheel hub is journalled by means of tapered roller bearings on the inner and outer carrier members respectively, these bearings being axially located by means of a clamping member which is itself secured by bolts or screws to the outer carrier member.

6. A hub drive as claimed in Claims 3 and 5 in which the breaking torque reaction is transmitted through the said bolts or screws comprise the anchorage pins for the second set of brake plates.

7. A hub drive as claimed in Claim 5 or Claim 6 in which a set of removable shims is interposed between the clamping member and the outer carrier member to provide for axial adjustment of the bearings.

8. A hub drive comprising a reduction gear mechanism, a hub and a friction brake, substantially as specifically described herein with reference to the accompanying drawings.

9. A motor-in-wheel unit which comprises a motor housing provided with flange means for mounting the unit on a vehicle chassis, and a driving motor housed in the motor housing, the unit being provided with a hub drive as claimed in any one of Claims 1 to 7 whose inner carrier member is fixedly mounted on one end of the motor housing, the input shaft being integral with or coupled to the motor shaft to be driven by the driving motor, and a wheel which is mounted on the hub of the hub drive and whose rim surrounds the motor housing.

10. A motor-in-wheel unit as claimed in Claim 9 in which for operating the brake an elongated longitudinally - movable operating member extends to the brake through aligned axial bores in the motor shaft and the input shaft, the operating member being coupled at its end remote from the brake to an external brake actuating means.

11. A motor-in-wheel unit as claimed in Claim 10 including hydraulic actuator means arranged to transmit an actuating thrust to the brake through hydraulic fluid contained in communicating bores in the motor shaft and the input shaft for actuating the brake.

12. A motor-in-wheel unit substantially as specifically described herein with reference to the accompanying drawings.

KILBURN & STRODE,
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Agents for the Applicants.

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1559276 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

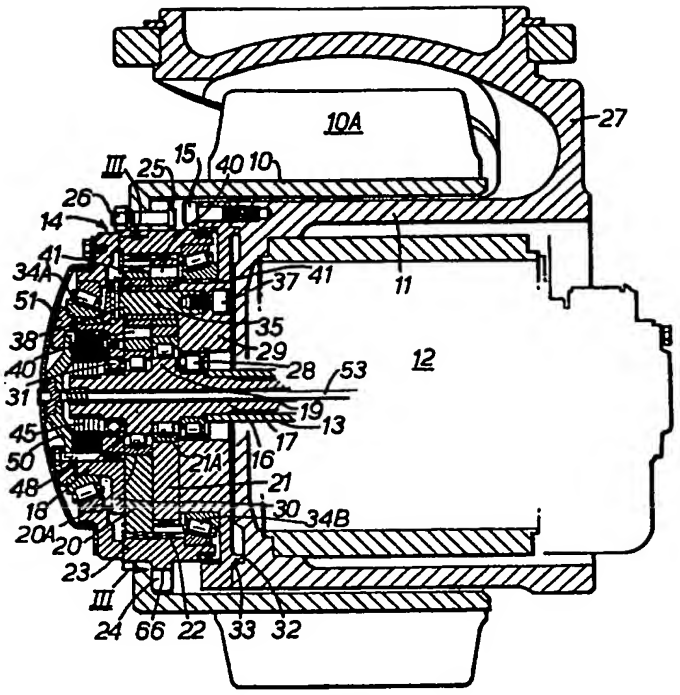

FIG. 1.

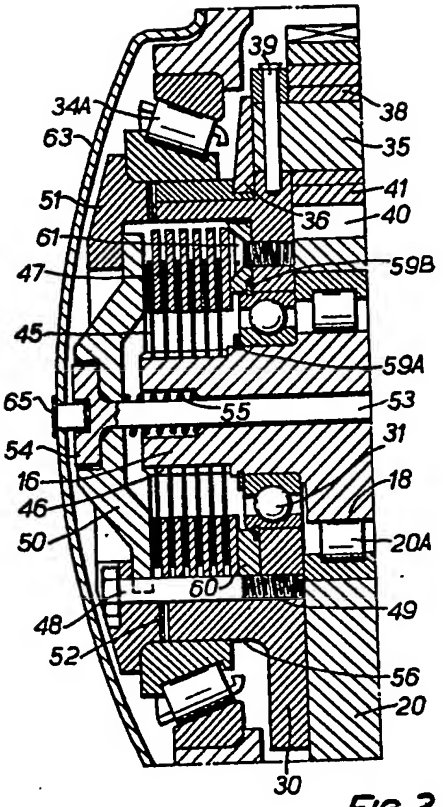
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FIG. 2.

1559276 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

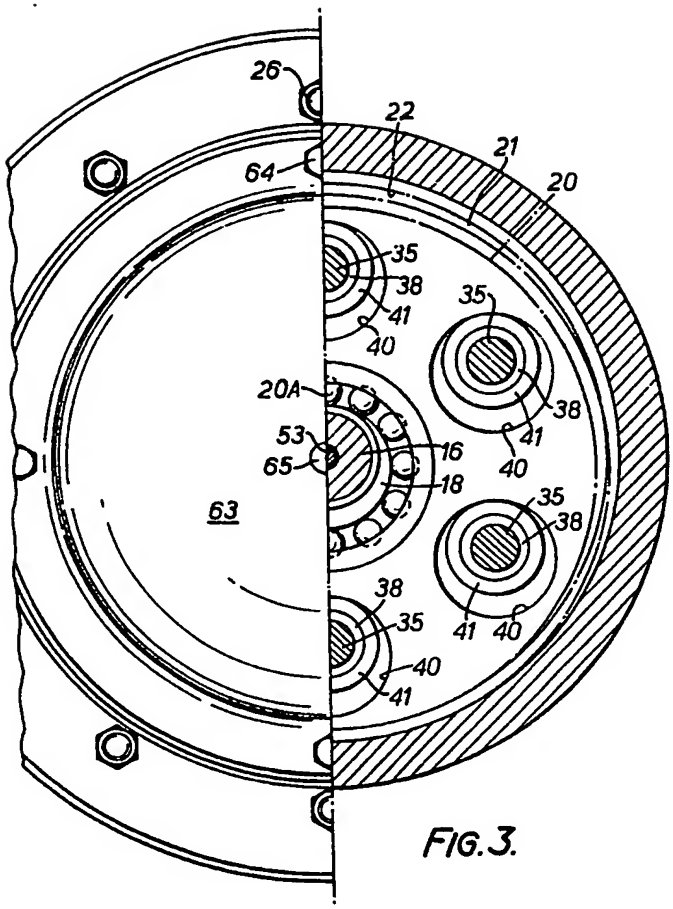

FIG. 3.